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VOC Emissions from Gas Powered Leaf Blowers in the Chicago Metropolitan Region

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Executive Summary

The Waste Management & Research Center estimated emissions from leaf blowers under three different policy scenarios for the Chicago metropolitan region: (1) a baseline that assumes no local ordinances have been enacted, (2) the adoption of an *aggressive* ordinance, which prohibits the use of leaf blowers between May 1 and September 30 and (3) the adoption of a *moderate* ordinance, which accelerates the purchase of low emission, gasoline powered leaf blowers. Under an aggressive policy scenario, VOC emissions from leaf blowers can be cut by over 64% from the baseline scenario. Under the moderate scenario, VOC emission will be reduced, but with diminishing effectiveness. For example, VOC emissions would be reduced by 7.3% from baseline in 2008 and only by 3.7% from baseline in 2009.

The villages of Lake Bluff, Wilmette and Oak Park have enacted leaf blower restrictions. Wilmette prohibits the use of gasoline-powered leaf blowers between May 15 and September 30 and restricts their use to 30 minutes on ½ acre lots or smaller during the remainder of the year. The Wilmette ordinance closely resembles the aggressive policy. Oak Park prohibits the use of all gasoline powered leaf blowers from emanating more than 65 decibels or failing to satisfy the most stringent federal regulations between June 1 and October 1. The Oak Park ordinance closely resembles the moderate policy. The Lake Bluff ordinance prohibits the use of gasoline powered leaf blowers early in the evening and at night. The ordinance also prohibits the simultaneous use of more than one gasoline powered leaf blower on a lot during the summer.

Introduction

The Clean Air Counts Initiative is a public/private partnership that has a goal of improving air quality by reducing emissions of smog precursors, such as nitrogen oxides (NOx) and volatile organic compounds (VOC) in the Chicago metropolitan region[1]. Numerous businesses, organizations, governments and citizens have joined Clean Air Counts and adopted strategies to reduce air emissions. These strategies include using low VOC paints, low VOC cleaners and energy efficient lighting[2]. Clean Air Counts tracks the implementation of these strategies and quantifies the reductions in air emissions.

Seeking to go beyond the current initiative strategies, local government participants are exploring municipal policy options that can further reduce smog precursors in their towns. Specifically, Clean Air Counts has asked the Waste Management & Research Center (WMRC) to model the effects of potential leaf blower ordinances. Using a municipal ordinance to reduce emissions from a gas powered leaf blower is a relatively new concept. Therefore, the results of this project can be used to aid in policy development. Within the Chicago metropolitan region, the villages of Lake Bluff, Wilmette and Oak Park currently have leaf blower ordinances. These policies have been written primarily with the intent to reduce noise pollution.

The first part of this report discusses local ordinances that affect the use of leaf blowers and the federal regulations that apply to leaf blower manufacturers. Local ordinances can affect the selection at the time of purchase as well as when and how leaf blowers are used. The United States Environmental Projection Agency (USEPA) is responsible for establishing regulations that govern the design and the maximum allowable emissions rate from an individual leaf blower.

The second part of the report presents emission estimates for leaf blowers under three different local policy scenarios: (1) a baseline that assumes no local ordinances have been enacted, (2) the adoption of an *aggressive* ordinance and (3) the adoption of a *moderate* ordinance. The estimates were made using the USEPA's 2005 NONROAD Model. This report aggregates emissions estimates for the entire Chicago metropolitan region. However, the model results for the three policy scenarios can be applied on an individual municipality basis. Please refer to Appendix A for additional details. Also, for simplicity, the report only presents VOC emission data. Corresponding NOx data can be found in Appendix B.

Background

This section discusses both local ordinances and federal regulations that pertain to leaf blowers. Federal standards regulate maximum allowable emissions rates from leaf blowers and local ordinances typically focus on the use of leaf blowers.

[1] The Chicago metropolitan region refers to Cook, Du Page, Kane, Lake, Mc Henry and Will Counties.
[2] Descriptions of all strategies can be found at www.cleanaircounts.org.

Federal Emission Standards

In 1995, USEPA set allowable emission limits for VOC, carbon monoxide and NOx from small leaf blowers manufactured after Sept 1, 1997. These regulations are referred to as Phase 1. The USEPA estimates that engines complying with these regulations will have at least a 33% reduction in VOC emissions. The language on a leaf blower package or label may read to the effect, "this engine conforms to Phase 1 USEPA regulations" (U.S. EPA, 1998).

In 2000, USEPA adopted additional hydrocarbon and NOx emission reductions for leaf blowers that were phased in between 2002 and 2006. These regulations are referred to as Phase 2. The Phase 2 standards resulted in a 70% reduction in hydrocarbon and NOx emissions over Phase 1 reductions, or 80% overall (U.S. EPA, 2000).

In 2007, USEPA proposed new evaporative emission standards to control fuel tank permeation, fuel line permeation and diffusion emissions. This proposal would result in a 45% reduction in evaporative losses. If adopted, the standards could go into effect for the 2011 or 2012 model year (U.S. EPA, 2007).

Local Ordinances

In the Chicago Region, the Villages of Lake Bluff, Wilmette and Oak Park have enacted leaf blower restrictions. It appears that all three communities have enacted their restrictions with the primary intent of minimizing disturbances to the peace. Oak Park has also required that leaf blowers used in the village meet EPA regulations.

In 2006, Wilmette modified their village code to prohibit the use of gasoline-powered leaf blowers between May 15 and September 30 and restrict their use to 30 minutes on ½ acre lots or smaller during the remainder of the year. The regulation applies to both commercial and residential users. However, this prohibition does not apply to the Wilmette Park District or to roof, gutter and downspout cleaning. Wilmette had already previously prohibited the use of powered commercial lawn care equipment after 5 PM and on Sundays.

The Village of Oak Park enacted its ordinance in 2004. Oak Park prohibits the use of all gasoline powered leaf blowers from emanating more than 65 decibels or failing to satisfy the most stringent federal regulations between June 1 and October 1. The Village Manager can permit the use of gasoline powered leaf blowers during periods where it is in the best interests of public, health and safety, such as for a cleanup after severe weather. All equipment used between June 1 and October 1 must be annually registered with the village and demonstrated to emanate no more than 65 decibels and meet EPA emission standards. (Rozmus, 2007a).

In 2003, prior to enacting their current ordinance, Oak Park completely prohibited to use of gasoline powered leaf blowers during the summer season. In order to comply with this ordinance, commercial lawn care service providers switched to electric powered leaf blowers, rakes and brooms. The service providers submitted evidence that their labor costs increased by 25% due to the leaf blower prohibition. These costs were passed on to their customers. Given

this information, Oak Park decided in 2004 to adopt their current ordinance, which does allow the use of leaf blowers as long as the equipments meets the most current EPA standards and does not emanate more than 65 decibels (Rozmus, 2007b).

The Village of Lake Bluff enacted its ordinance in 1999. The Lake Bluff ordinance prohibits the use of gasoline powered leaf blowers early in the evening and at night. The ordinance also prohibits the simultaneous use of more than one gasoline powered leaf blower on a lot during the summer. The Lake Bluff ordinance exempts golf courses, ordinary public property maintenance activities occurring at least 100 feet from the property line, and clean-up activities necessary as a result of extreme weather conditions as determined by the Village Administrator.

Methods

The USEPA's 2005 NONROAD Emission Model, 2005 version, was used to estimate leaf blowers emissions for each of the scenarios studied. The NONROAD Model correlates residential leaf blower usage based on the total number of single and two family homes in a county. Similarly, the NONROAD Model correlates commercial leaf blowers based on the number of employees in a given county that work in the landscaping industry. The NONROAD Model uses housing and employment data collected by the US Census Bureau (U.S. EPA, 2005b). The NONROAD Model also provides assumptions for the size, age and emissions profiles of leaf blower motors and their hours of operation. These assumptions can vary by time of year and geographical location. The NONROAD Model has been customized based on the Chicago metropolitan region's weather conditions and gasoline formulation (Appendix C).

The NONROAD Model has a few limitations. The model does not provide emission estimates for regions smaller than county level. Therefore, the emissions for individual towns have been estimated by multiplying the per capita countywide emissions data by the population of that town. Refer to Appendix B for additional details. The NONROAD Model also has a limitation on estimating leaf blower emissions from municipal operations such as for maintaining parks and schools. The implicit implication is that emissions from municipal operations are proportional to emissions from commercial activity.

Results and Discussion

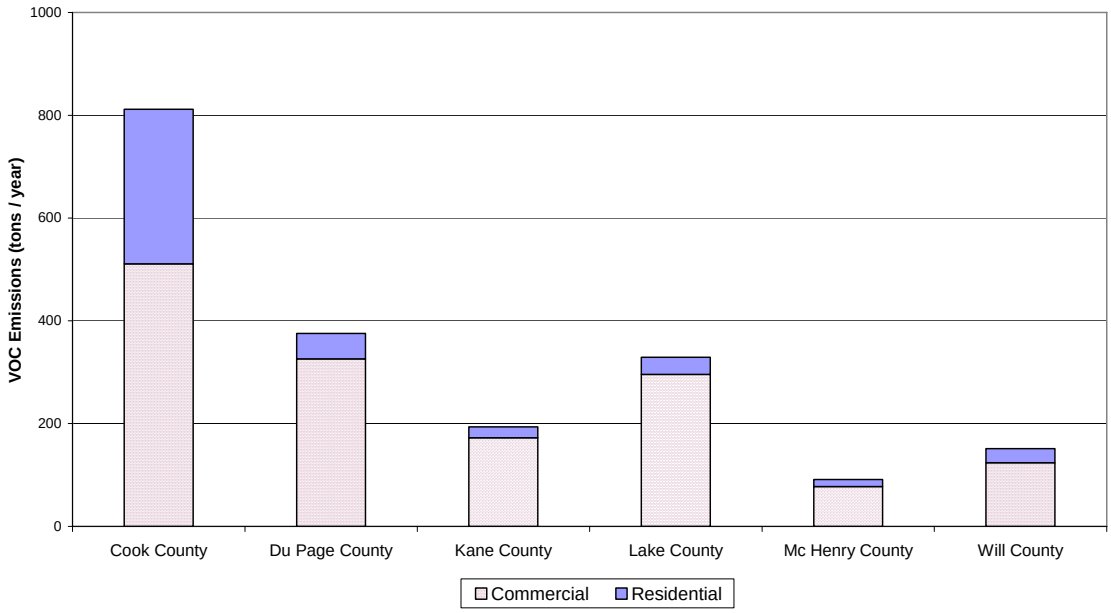
The NONROAD Model suggests that gasoline powered leaf blowers are a significant source of VOC emissions. In 2002, leaf blowers accounted for 14.7% of the total VOC emissions from lawn and garden equipment and 1.5% of the total anthropogenic VOC emissions in the region[3]. However, gasoline powered leaf blowers are a less significant source of NOx. In 2002, leaf blowers accounted for 7.2% of the total NOX emissions from lawn and garden equipment and 0.1% of the total anthropogenic NOx emissions in the region. A comprehensive inventory and discussion of the region's air pollution sources for 2002 is given by the Illinois Environmental Protection Agency[4]. See References for additional information.

[3] Anthropogenic emissions refer to emission caused by man as opposed to nature.

[4] A comprehensive inventory of air pollution sources in the region is not currently available for years following 2002.

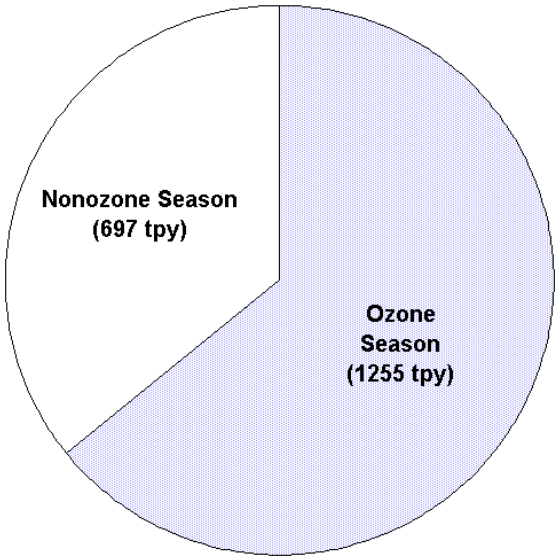
In 2006, the VOC emissions for leaf blowers were estimated to be 1,952 tons per year (Figure 1). This is equivalent to the VOC emissions from more than 100,000 passenger cars (U.S. EPA, 2005a). Commercial sources account for 77% of the VOC emissions. The remaining emissions are from residential sources. Therefore, policies that influence the commercial lawn care industry could have a greater effect on air quality than ones that target the residential use of leaf blowers.

Figure 1: 2006 VOC Emissions from Leaf Blowers in the Chicago Region



Over 60% of the VOC emissions occur during the ozone season, which runs from May 1 to September 31 (Figure 2). This is not surprising because there is only limited lawn care during the winter months. Therefore, policies that only target the summer months can be still be effective.

Figure 2: Seasonal Breakdown of VOC Emissions from Leaf Blowers in the Chicago Region for 2006



Model Policies

WMRC modeled the effect of both an aggressive and a moderate ordinance on leaf blower emissions and compared them to a baseline scenario that assumes no local policies have been enacted. These ordinances were chosen to broadly demonstrate the potential effect that municipalities can have on reducing leaf blower emissions. The scenarios do not necessarily represent the best policy choices for a given town once enforcement and quality of life issues are considered. The results for the Chicago region are shown in Figure 3. In all three scenarios, emissions trend downward between 2006 and 2009 because the model assumes that over time, people will replace their older equipment with new leaf blowers, which are required to have lower emission rates. All emission estimates presented for the moderate and aggressive ordinances are based on the assumption of 100% compliance.

In the aggressive scenario, it is assumed that all municipalities in the Chicago metropolitan region prohibit the use of gasoline powered leaf blowers by residents and commercial lawn services as well as municipal employees during the ozone season. The aggressive policy is similar to Wilmette's ordinance (see Table 1)[5]. The aggressive policy would still allow the use of gasoline powered leaf blowers during non-ozone season months, including in October and November when the majority of trees lose their leaves. If the aggressive policy were adopted,

[5] Ozone season begins on May 1. Wilmette's ban on using leaf blowers take effect on May 15.

then VOC emissions from leaf blowers in 2008 would be 536 tons versus 1,495 tons with no policy change. This represents a 64% reduction in annual emissions.

While having the potential to significantly reduce leaf blower emissions, enforcing leaf blower prohibitions could prove to be challenging. It is not anticipated that many municipalities would have the manpower or political desire to fully enforce an aggressive policy. Therefore, this scenario might require voluntary compliance. However, even with only partial compliance, the aggressive policy could be effective at significantly reducing leaf blower emissions during the ozone season even if it does not completely eliminate emissions from leaf blowers.

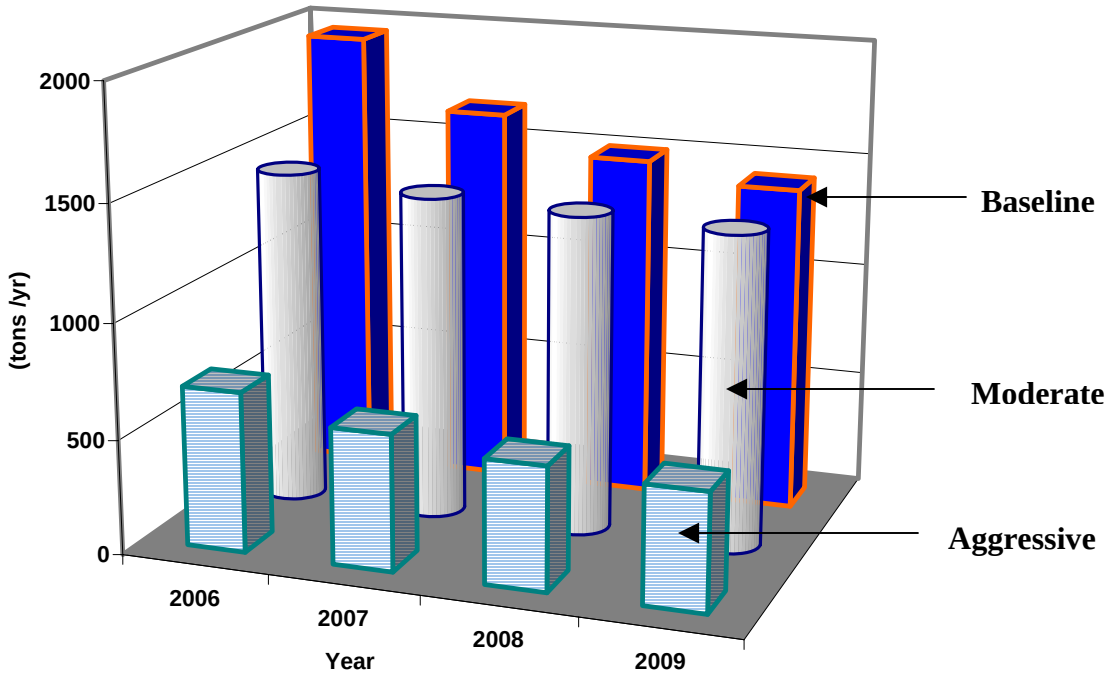
Table 1: Policy Summary

	Ozone Season		Non-Ozone Season	
	Residential	**Commercial**	**Residential**	**Commercial**
Aggressive	Total ban	Total ban	None	None
Wilmette	Total ban	Total ban	Max use of 30 min	Max use of 30 min
Moderate	None	Only Phase II blowers	None	Only Phase II blowers
Oak Park	Only Phase II blowers	Only Phase II blowers	Only Phase II blowers	Only Phase II blowers
Lake Bluff	Only 1 gasoline powered leaf blower at a time and only during the day	Only 1 gasoline powered leaf blower at a time and only during the day	None	None

In the moderate scenario, it is mandated that all professional lawn care companies use gasoline powered leaf blowers that comply with the latest USEPA emission standard (Phase II). In practical terms, lawn care professionals would have to replace all of their older gasoline powered leaf blowers with ones that were manufactured within the last two to three years. The moderate policy might provide less hardship for lawn care professionals because they would be able to use leaf blowers that comply with Phase III standards at all times. Unlike the Oak Park ordinance, the moderate policy would not affect residential leaf blower usage (Table 1).

If the moderate scenario were adopted, then VOC emission from leaf blowers in 2008 would be 1,387 tons. This represents a 7.3% reduction from baseline. The moderate policy would have diminishing returns in future years because even without a policy change, commercial users will eventually replace their older leaf blowers with new ones. For example by 2009, the moderate policy would only result in a 3.7% in VOC emissions from baseline. However, the moderate policy could prove to be more significant in the future. The USEPA has proposed that leaf blower manufacturers comply with Phase III standards beginning in 2011 and 2012. If adopted beforehand, the moderate policy could significantly accelerate the Phase III reductions. However, the benefits of the moderate policy in conjunction with Phase III standards cannot be quantified at this time due to limits in the NONROAD Model.

Figure 3:VOC Emissions from Leaf Blowers in the Chicago Region - Policy Scenarios



VOC Emission Reductions from the Baseline Scenario

	2006	2007	2008	2009
Aggressive Scenario	64.3%	64.2%	64.2%	64.1%
Moderate Scenario	25.0%	14.7%	7.3%	3.7%

Conclusion

The usage of leaf blowers is a significant source of VOC and NOx emissions in the Chicago metropolitan region. Three local governments have enacted prohibitions against leaf blowers and others may do so in the future. Under an aggressive policy scenario where leaf blower usage would be prohibited during Ozone Season, VOC emissions from leaf blowers can be cut by over 64%. Under the moderate scenario where the purchase of Phase II, gasoline powered leaf blowers would be accelerated, VOC emission could also be reduced with diminishing effectiveness. For example, under a moderate scenario, VOC emissions would be reduced by 7.3% in 2008 and only by 3.7% in 2009. When choosing whether to enact a leaf blower ordinance, local governments will also have to take into account enforceability, convenience and noise pollution considerations. Carefully balancing the needs of the environment and all stakeholders will lead to the most effective policy.

Appendix A: Estimating Municipal Emissions from Leaf Blowers

The Nonroad Emission Model does not provide emission estimates for regions smaller than county level. However, the emissions for an individual municipality can be estimated by multiplying the per capita countywide emissions data by the town's population. Population was chosen as the scaling factor because population data for municipalities is readily available from the US Census Bureau. Other scaling factors, such as number of employees in the lawn care industry and number of single and dual family homes, were also considered. Although they have the potential for increased accuracy, these scaling factors cannot be used because this data is not readily available for all of the towns in the Chicago metropolitan region.

A generalized formula that can be used to calculate emission is given below.

$E = e \times P / 100{,}000$

Where:

E = Emissions (in tons / yr)

e = Per capita county emissions (in tons/yr/ 100,000 people)

P= Town population

The per capita county emissions (e) can be found in Appendix D.

The population data (P) for towns in Illinois can be found on the US Census Bureau website. It is best to use population estimates as of July 1, 2006 because the per capita county emissions were calculated using data from this date.

http://www.census.gov/popest/cities/tables/SUB-EST2006-04-17.xls

Two sample calculations are given on the following pages.

Sample Calculations

A. Calculate the VOC emissions reduction from leaf blowers for the City of Wilmette under the aggressive policy scenario for 2008.

Step 1: The reductions (E_r) can be calculated by subtracting the annual VOC emissions under the aggressive policy (e_a) from the baseline scenario (e_b). The following formula can be used:

$E_r = (e_b - e_a) \times P / 100{,}000$

Step 2: Look up the 2008 per capita VOC emissions for Cook County in Table D3 in Appendix D for the baseline (e_b) and aggressive (e_a) policy scenarios. For reference, Table D3 has been reproduced here. Wilmette is located in Cook County.

Table D3: VOC Emissions from Leaf Blowers in Cook County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Baseline	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	521.3	414.3	0	9.857	7.834	0
	2007	440.2	387.0	0	8.323	7.318	0
	2008	393.8	368.2	0	7.446	6.962	0
	2009	370.1	358.9	0	6.998	6.786	0
Non-Ozone Season	2006	290.2	231.5	290.2	5.487	4.377	5.487
	2007	246.1	216.7	246.1	4.653	4.097	4.653
	2008	220.8	209.5	220.8	4.175	3.961	4.175
	2009	207.9	201.6	207.9	3.931	3.812	3.931
Annual	2006	811.5	645.8	290.2	15.34	12.21	5.49
	2007	686.3	603.7	246.1	12.98	11.42	4.65
	2008	614.6	577.7	220.8	11.62	10.92	4.17
	2009	578.0	560.5	207.9	10.93	10.60	3.93

$e_b = 11.62$ $e_a = 4.17$

Step 3: Look up the population of Wilmette as of July 1, 2006 from the US Census Bureau website (See above for web address).

$P = 26{,}737$ people

Step 4: Complete the calculation.

$E_r = (e_b - e_a) \times P / 100{,}000$

$= (11.62 - 4.17) \times 26{,}737 / 100{,}000$

$= 1.99$ tons /yr

Under the aggressive policy scenario, Wilmette would reduce their VOC emissions by 1.99 tons in 2008. This is a 64% reduction. Is the rate of compliance assumed to be 100%?

B. Calculate the NOx emissions reduction from leaf blowers for the City of Oak Park under the moderate policy scenario for the 2007 Ozone Season.

Step 1: The reductions (E_r) can be calculated by subtracting the Ozone Season NOx emissions under the moderate policy (e_m) from the baseline scenario (e_b). The formula is:

$$E_r = (e_b - e_m) \times P$$

Step 2: Look up the 2007 Ozone Season per capita NOx emissions for Cook County in Table D4 in Appendix D for the baseline (e_b) and moderate policy (e_m) scenarios. For reference, Table D4 has been reproduced here. Oak Park is located in Cook County.

Table D4: NOx Emissions from Leaf Blowers in Cook County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Baseline	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	54.2	34.7	0	1.025	0.656	0
	2007	52.5	35.6	0	0.993	0.673	0
	2008	51.1	36.4	0	0.966	0.688	0
	2009	49.8	37.1	0	0.942	0.702	0
Non-Ozone Season	2006	36.6	23.0	36.6	0.692	0.435	0.692
	2007	35.4	23.6	35.4	0.669	0.446	0.669
	2008	34.3	26.3	34.3	0.649	0.497	0.649
	2009	33.4	24.5	33.4	0.632	0.463	0.632
Annual	2006	90.8	57.7	36.6	1.717	1.091	0.692
	2007	87.9	59.2	35.4	1.662	1.119	0.669
	2008	85.4	62.7	34.3	1.615	1.186	0.649
	2009	83.2	61.6	33.4	1.573	1.165	0.632

$e_b = 0.993$ $E_m = 0.673$

Step 3: Look up the population of Oak Park as of July 1, 2006 from the US Census Bureau website (see above for web address).

$P = 50{,}372$ people

Sept 4: Complete the calculations.

$$E_r = (e_b - e_m) \times P$$
$$= (0.993 - 0.673) \times 50{,}372 / 100{,}000$$
$$= 0.161 \text{ tons /yr}$$

Under the moderate policy scenario, Oak Park would reduce their emissions by 0.161 tons during the Ozone Season of 2007. This is a 32% reduction.

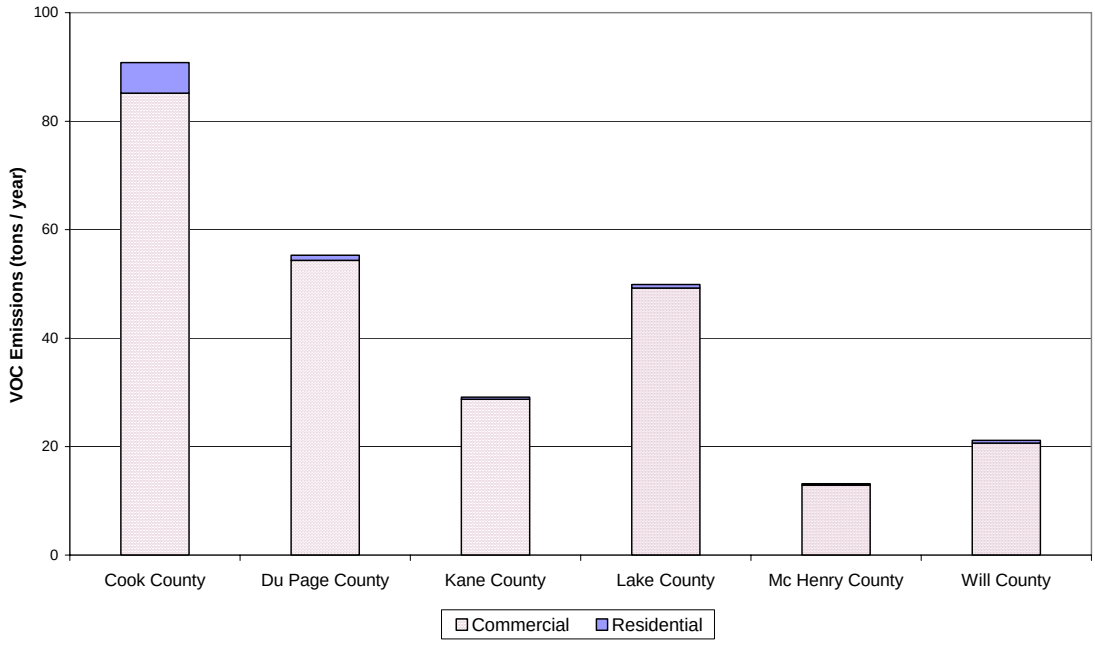
Appendix B: Nitrogen Oxide Emissions

Estimates for NOx emissions from leaf blower emissions in the Chicago metropolitan region are discussed below.

Baseline Emissions

In 2006, the NOx emissions for leaf blowers were estimated to be 260 tons per year (Figure B1). This is equivalent to the NOx emissions from more than 20,000 passenger cars (U.S. EPA, 2005a). Commercial sources account for 96% of the NOx emissions. The remaining emissions are from residential sources.

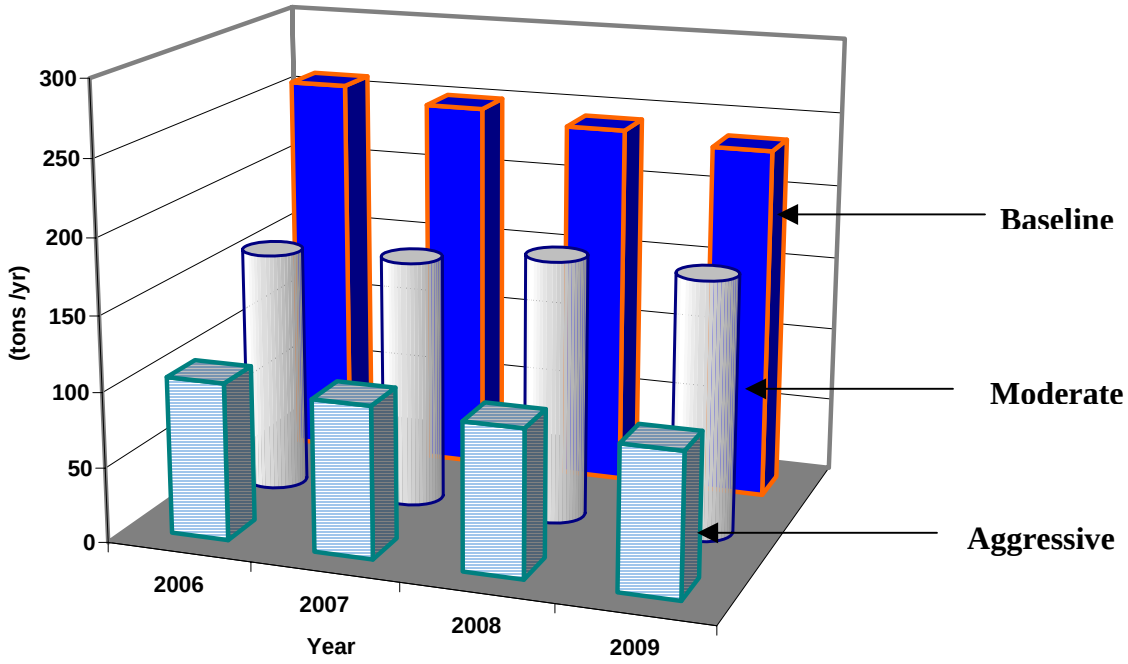
Figure B1: 2006 VOC Emissions from Leaf Blowers in the Chicago Region



Model Policies

WMRC modeled the effect of both an aggressive and a moderate ordinance on NOx emissions from leaf blowers and compared them to a baseline scenario that assumes no local policies have been enacted (Figure B2). If the aggressive policy were adopted, then NOx emissions from leaf blowers in 2008 would be 98 tons versus 242 tons with no policy change. This represents a 60% reduction. If the moderate scenario were adopted, then NOx emission from leaf blowers in 2008 would be 1,387 tons. This represents a 28% reduction from baseline.

Figure B2: NOx Emissions from Leaf Blowers in the Chicago Region - Policy Scenarios



NOx Emission Reductions from the Baseline Scenario

	2006	2007	2008	2009
Aggressive Scenario	59.6%	59.7%	59.7%	59.7%
Moderate Scenario	37.6%	33.8%	27.7%	27.0%

Appendix C: NONROADS Input Parameters

WMRC used the NONROAD model to estimate leaf blower emissions by county. The inputs used in the NONROAD model are shown in Table D1. Annual emissions were calculated by summing results from seasonal and monthly model runs. Because the Chicago metropolitan region's gasoline formulation is different during the Ozone Season than it is during the Non-Ozone Season, the input parameters varied slightly based on time of year. The months of June, July and August were combined into the Summer Season. The months of December, January and February were combined into the Winter Season.

Table D1: NONROAD Model Input Parameters [6, 7, 8]

Season		Fuel RVP (psi)	Gasoline Sulfur Content (%)	Diesel Sulfur Content (%)	O_2 wt %	Min Temp (F)	Max Temp (F)	Avg Temp (F)
Ozone	**Summer**	6.7	0.0247	0.0375	3.61	60.9	81.3	71.1
	May	6.7	0.0247	0.0375	3.61	47.5	69.9	58.7
	September	6.7	0.0247	0.0375	3.61	53.7	73.9	63.8
Non-Ozone	**Winter**	14	0.0247	0.0375	3.61	18.0	32.9	25.5
	March	14	0.0247	0.0375	3.61	28.5	46.1	37.3
	April	14	0.0247	0.0375	3.61	37.5	58.0	47.8
	October	14	0.0247	0.0375	3.61	42.1	62.1	52.1
	November	14	0.0247	0.0375	3.61	31.6	47.1	39.3

[6] The fuel RVP (relative vapor pressure)_, gasoline sulfur content and diesel sulfur content for the Chicago metropolitan region were obtained from the Illinois Environmental Projection Agency (IEPA, 2002).

[7] The O_2 wt % was obtained from the United States Environmental Projection Agency. Available online at http://www.epa.gov/otaq/regs/fuels/rfg/properf/chi-il.htm.

[8] The minimum, maximum and average temperatures were obtained from the National Weather Service. Available online at http://www.crh.noaa.gov/lot/climate/ord_norms.php.

Appendix D: Leaf Blower Emissions Data

VOC and NOx emissions from gasoline powered leaf blowers for each of the six counties in the Chicago region and for the area as a whole are given in Appendix D. The Ozone season includes the months of May, June, July, August and September. The remaining seven months are part of the Non-Ozone season. Per capita emissions were calculated using U.S Census Bureau population estimates as of July 1, 2006[9].

CHICAGO METROPOLITAN REGION

Table D1: VOC Emissions from Leaf Blowers in the Chicago Metropolitan Region

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	1255.3	939.9	0	14.929	11.178	0
	2007	1062.5	905.6	0	12.636	10.770	0
	2008	959.3	884.0	0	11.408	10.513	0
	2009	909.6	876.5	0	10.817	10.424	0
Non-Ozone Season	2006	697.0	523.7	697.0	8.289	6.228	8.289
	2007	592.0	505.4	593.0	7.040	6.010	7.052
	2008	535.7	502.5	535.7	6.371	5.976	6.371
	2009	508.6	489.9	508.6	6.048	5.826	6.048
Annual	2006	1952.3	1463.6	697.0	23.22	17.41	8.29
	2007	1654.5	1411.0	593.0	19.68	16.78	7.05
	2008	1495.0	1386.5	535.7	17.78	16.49	6.37
	2009	1418.2	1366.4	508.6	16.87	16.25	6.05

Table D2: NOx Emissions from Leaf Blowers in the Chicago Metropolitan Region

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	154.6	97.2	0	1.839	1.156	0
	2007	149.2	99.4	0	1.774	1.182	0
	2008	144.7	101.4	0	1.721	1.206	0
	2009	140.7	103.3	0	1.673	1.228	0
Non-Ozone Season	2006	104.9	64.9	104.9	1.248	0.772	1.248
	2007	100.9	66.3	100.9	1.200	0.788	1.200
	2008	97.7	74.0	97.7	1.162	0.880	1.162
	2009	94.9	68.8	94.9	1.129	0.818	1.129
Annual	2006	259.5	162.1	104.9	3.086	1.928	1.248
	2007	250.1	165.7	100.9	2.974	1.971	1.200
	2008	242.4	175.4	97.7	2.883	2.086	1.162
	2009	235.6	172.1	94.9	2.802	2.047	1.129

[9] U.S Census Bureau population estimates are online at http://www.census.gov/popest/cities/tables/SUB-EST2006-04-17.xls.

COOK COUNTY

Table D3: VOC Emissions from Leaf Blowers in Cook County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Baseline	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	521.3	414.3	0	9.857	7.834	0
	2007	440.2	387.0	0	8.323	7.318	0
	2008	393.8	368.2	0	7.446	6.962	0
	2009	370.1	358.9	0	6.998	6.786	0
Non-Ozone Season	2006	290.2	231.5	290.2	5.487	4.377	5.487
	2007	246.1	216.7	246.1	4.653	4.097	4.653
	2008	220.8	209.5	220.8	4.175	3.961	4.175
	2009	207.9	201.6	207.9	3.931	3.812	3.931
Annual	2006	811.5	645.8	290.2	15.34	12.21	5.49
	2007	686.3	603.7	246.1	12.98	11.42	4.65
	2008	614.6	577.7	220.8	11.62	10.92	4.17
	2009	578.0	560.5	207.9	10.93	10.60	3.93

Table D4: NOx Emissions from Leaf Blowers in Cook County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Baseline	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	54.2	34.7	0	1.025	0.656	0
	2007	52.5	35.6	0	0.993	0.673	0
	2008	51.1	36.4	0	0.966	0.688	0
	2009	49.8	37.1	0	0.942	0.702	0
Non-Ozone Season	2006	36.6	23.0	36.6	0.692	0.435	0.692
	2007	35.4	23.6	35.4	0.669	0.446	0.669
	2008	34.3	26.3	34.3	0.649	0.497	0.649
	2009	33.4	24.5	33.4	0.632	0.463	0.632
Annual	2006	90.8	57.7	36.6	1.717	1.091	0.692
	2007	87.9	59.2	35.4	1.662	1.119	0.669
	2008	85.4	62.7	34.3	1.615	1.186	0.649
	2009	83.2	61.6	33.4	1.573	1.165	0.632

DUPAGE COUNTY

Table D5: VOC Emissions from Leaf Blowers in DuPage County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	241.5	173.2	0	25.893	18.570	0
	2007	204.7	170.7	0	21.948	18.302	0
	2008	186.0	169.7	0	19.943	18.195	0
	2009	177.4	170.2	0	19.021	18.249	0
Non-Ozone Season	2006	133.8	96.3	133.8	14.346	10.325	14.346
	2007	113.8	95.1	113.8	12.202	10.197	12.202
	2008	103.6	96.4	103.6	11.108	10.336	11.108
	2009	98.9	94.8	98.9	10.604	10.164	10.604
Annual	2006	375.3	269.5	133.8	40.24	28.90	14.35
	2007	318.5	265.8	113.8	34.15	28.50	12.20
	2008	289.6	266.1	103.6	31.05	28.53	11.11
	2009	276.3	265.0	98.9	29.62	28.41	10.60

Table D6: NOx Emissions from Leaf Blowers in DuPage County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	32.9	20.5	0	3.528	2.198	0
	2007	31.7	20.9	0	3.399	2.241	0
	2008	30.7	21.3	0	3.292	2.284	0
	2009	29.8	21.7	0	3.195	2.327	0
Non-Ozone Season	2006	22.4	13.7	22.4	2.402	1.469	2.402
	2007	21.5	14.0	21.5	2.305	1.501	2.305
	2008	20.8	15.7	20.8	2.230	1.683	2.230
	2009	20.2	14.5	20.2	2.166	1.555	2.166
Annual	2006	55.3	34.2	22.4	5.929	3.667	2.402
	2007	53.2	34.9	21.5	5.704	3.742	2.305
	2008	51.5	37.0	20.8	5.522	3.967	2.230
	2009	50.0	36.2	20.2	5.361	3.881	2.166

KANE COUNTY

Table D7: VOC Emissions from Leaf Blowers in Kane County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	124.6	88.5	0	25.236	17.925	0
	2007	105.7	87.8	0	21.408	17.783	0
	2008	96.2	87.5	0	19.484	17.722	0
	2009	91.8	88.0	0	18.593	17.823	0
Non-Ozone Season	2006	69.1	49.2	69.1	13.995	9.965	13.995
	2007	58.7	48.8	59.7	11.889	9.884	12.092
	2008	53.5	49.7	53.5	10.836	10.066	10.836
	2009	51.2	49.0	51.2	10.370	9.924	10.370
Annual	2006	193.7	137.7	69.1	39.23	27.89	14.00
	2007	164.4	136.6	59.7	33.30	27.67	12.09
	2008	149.7	137.2	53.5	30.32	27.79	10.84
	2009	143.0	137.0	51.2	28.96	27.75	10.37

Table D8: NOx Emissions from Leaf Blowers in Kane County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	17.4	10.8	0	3.524	2.187	0
	2007	16.7	11.0	0	3.382	2.228	0
	2008	16.1	11.2	0	3.261	2.268	0
	2009	15.7	11.4	0	3.180	2.309	0
Non-Ozone Season	2006	11.8	7.2	11.8	2.390	1.458	2.390
	2007	11.3	7.4	11.3	2.289	1.499	2.289
	2008	10.9	8.2	10.9	2.208	1.661	2.208
	2009	10.6	7.6	10.6	2.147	1.539	2.147
Annual	2006	29.2	18.0	11.8	5.914	3.646	2.390
	2007	28.0	18.4	11.3	5.671	3.727	2.289
	2008	27.0	19.4	10.9	5.469	3.929	2.208
	2009	26.3	19.0	10.6	5.327	3.848	2.147

LAKE COUNTY

Table D9: VOC Emissions from Leaf Blowers in Lake County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	211.8	149.9	0	29.702	21.022	0
	2007	179.6	148.8	0	25.187	20.867	0
	2008	163.5	148.7	0	22.929	20.853	0
	2009	156.2	149.7	0	21.905	20.994	0
Non-Ozone Season	2006	117.3	83.3	117.3	16.450	11.682	16.450
	2007	99.8	82.8	99.8	13.996	11.612	13.996
	2008	91.0	84.5	91.0	12.762	11.850	12.762
	2009	87.0	83.3	87.0	12.201	11.682	12.201
Annual	2006	329.1	233.2	117.3	46.15	32.70	16.45
	2007	279.4	231.6	99.8	39.18	32.48	14.00
	2008	254.5	233.2	91.0	35.69	32.70	12.76
	2009	243.2	233.0	87.0	34.11	32.68	12.20

Table D10: NOx Emissions from Leaf Blowers in Lake County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	29.7	18.4	0	4.165	2.580	0
	2007	28.6	18.8	0	4.011	2.636	0
	2008	27.7	19.2	0	3.885	2.693	0
	2009	26.9	19.5	0	3.772	2.735	0
Non-Ozone Season	2006	20.2	12.4	20.2	2.833	1.739	2.833
	2007	19.4	12.6	19.4	2.721	1.767	2.721
	2008	18.8	14.1	18.8	2.636	1.977	2.636
	2009	18.2	13.1	18.2	2.552	1.837	2.552
Annual	2006	49.9	30.8	20.2	6.998	4.319	2.833
	2007	48.0	31.4	19.4	6.731	4.403	2.721
	2008	46.5	33.3	18.8	6.521	4.670	2.636
	2009	45.1	32.6	18.2	6.325	4.572	2.552

MCHENRY COUNTY

Table D11: VOC Emissions from Leaf Blowers in McHenry County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	58.8	42.7	0	18.824	13.670	0
	2007	49.9	41.8	0	15.974	13.381	0
	2008	45.2	41.4	0	14.470	13.253	0
	2009	43.1	41.4	0	13.798	13.253	0
Non-Ozone Season	2006	32.6	23.7	32.6	10.436	7.587	10.436
	2007	27.7	23.3	27.7	8.868	7.459	8.868
	2008	25.2	23.5	25.2	8.067	7.523	8.067
	2009	24.0	23.1	24.0	7.683	7.395	7.683
Annual	2006	91.4	66.4	32.6	29.26	21.26	10.44
	2007	77.6	65.1	27.7	24.84	20.84	8.87
	2008	70.4	64.9	25.2	22.54	20.78	8.07
	2009	67.1	64.5	24.0	21.48	20.65	7.68

Table D12: NOx Emissions from Leaf Blowers in McHenry County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	7.8	4.9	0	2.497	1.569	0
	2007	7.5	5.0	0	2.401	1.601	0
	2008	7.3	5.1	0	2.337	1.633	0
	2009	7.1	5.2	0	2.273	1.665	0
Non-Ozone Season	2006	5.3	3.3	5.3	1.697	1.056	1.697
	2007	5.1	3.3	5.1	1.633	1.056	1.633
	2008	4.9	3.7	4.9	1.569	1.184	1.569
	2009	4.8	3.5	4.8	1.537	1.120	1.537
Annual	2006	13.1	8.2	5.3	4.194	2.625	1.697
	2007	12.6	8.3	5.1	4.034	2.657	1.633
	2008	12.2	8.8	4.9	3.906	2.817	1.569
	2009	11.9	8.7	4.8	3.810	2.785	1.537

WILL COUNTY

Table D13: VOC Emissions from Leaf Blowers in Will County

		VOC Emission (tons/yr)			Per capita VOC Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	97.3	71.3	0	14.561	10.670	0
	2007	82.4	69.5	0	12.331	10.401	0
	2008	74.6	68.5	0	11.164	10.251	0
	2009	71.0	68.3	0	10.625	10.221	0
Non-Ozone Season	2006	54.0	39.7	54.0	8.081	5.941	8.081
	2007	45.9	38.7	45.9	6.869	5.792	6.869
	2008	41.6	38.9	41.6	6.226	5.821	6.226
	2009	39.6	38.1	39.6	5.926	5.702	5.926
Annual	2006	151.3	111.0	54.0	22.64	16.61	8.08
	2007	128.3	108.2	45.9	19.20	16.19	6.87
	2008	116.2	107.4	41.6	17.39	16.07	6.23
	2009	110.6	106.4	39.6	16.55	15.92	5.93

Table D14: NOx Emissions from Leaf Blowers in Will County

		NOx Emission (tons/yr)			Per capita NOx Emissions (tons/yr/ 100,000 people)		
		Policy Scenario			Policy Scenario		
		Base	Moderate	Aggressive	Base	Moderate	Aggressive
Ozone Season	2006	12.6	7.9	0	1.886	1.182	0
	2007	12.2	8.1	0	1.826	1.212	0
	2008	11.8	8.2	0	1.766	1.227	0
	2009	11.4	8.4	0	1.706	1.257	0
Non-Ozone Season	2006	8.6	5.3	8.6	1.287	0.793	1.287
	2007	8.2	5.4	8.2	1.227	0.808	1.227
	2008	8.0	6.0	8.0	1.197	0.898	1.197
	2009	7.7	5.6	7.7	1.152	0.838	1.152
Annual	2006	21.2	13.2	8.6	3.173	1.975	1.287
	2007	20.4	13.5	8.2	3.053	2.020	1.227
	2008	19.8	14.2	8.0	2.963	2.125	1.197
	2009	19.1	14.0	7.7	2.858	2.095	1.152

References

Illinois Environmental Protection Agency. *Illinois Base Year Ozone Inventory for 2002: Draft.* Springfield, IL: IL Environmental Protection Agency, 2006. (Online at http://www.epa.state.il.us/air/sip/il-base-o3-inventory-2002.pdf)

Rozmus, Karen. "Anti-Idling Study and Leaf Blower questions." E-mail to author. 15 Jul 2007a.

Rozmus, Karen. "Leaf Blower Policy Report for Review." E-mail to author. 20 Dec 2007b.

United States Environmental Projection Agency Office of Transportation and Air Quality. *Emission Facts. Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks.* Washington, DC: U.S. Environmental Protection Agency, 2005a. (Online at https://www.whatcomsmarttrips.org/pdf/Emission Facts 2005.pdf).

United States Environmental Protection Agency, Air and Radiation. *Geographical Allocation of Nonroad Engine Population Data to the State and County Level.* Washington, DC : U.S. Environmental Protection Agency, 2005b. (Online at http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05021.pdf).

United States Environmental Protection Agency Office of Transportation and Air Quality. *Proposed Emission Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels.* Washington, DC : U.S. Environmental Protection Agency, 2007. (Online at http://www.epa.gov/otaq/regs/nonroad/marinesi-equipld/420f07032.pdf).

United States Environmental Protection Agency, Air and Radiation. *Regulatory Announcement. Final Phase 2 Standards for Small Spark-Ignition Handheld Engines).* Washington, DC : U.S. Environmental Protection Agency, 2000. (Online athttp://epa.gov/otaq/regs/nonroad/equip-ld/hhsfrm/f00007.pdf).

United States Environmental Protection Agency Office of Mobile Sources. *Small Engine Emissions Standards: Answers to Commonly Asked Questions from Dealers and Distributors.* Washington, DC : U.S. Environmental Protection Agency, 1998.(Online at http://www.epa.gov/otaq/consumer/f98025a.pdf) .